Skibgræs

*Skibgræs* explores the relationship between energy production and the rich history of shipbuilding on the Refshaleøen site and in Denmark. Through explorations of Copenhagen’s trademark 56 set ship curves, *Skibgræs* evolved as a deconstruction of the historic curve set. Each curve became separated into individual curved lines, thickening into 0.5 meter marine grade steel H-beams. *Skibgræs* rises from the drosscape as ribbons undulating through the landscape, threading and connecting the greater Copenhagen area with Refshaleøen. The proposal references the graceful yet sturdy nature of Viking vessels and provides a visual reference point, culminating to a monument of Scandinavian cultural heritage.

The monument’s 70-meter height also forges a juxtaposed relationship with energy production in and around the site by visually aligning with smokestacks and wind turbines. Ground level interplay allows the ribbons and monument to become anchored, undulating to create moments for pedestrians to interact with the ribbons and the surrounding *Miscanthus giganteus.* *Skibgræs* generates energy with both the harvesting of *Miscanthus* and flexible solar panels that ride the top of the ribbons, forming solar ribbons. The combined strategies of sustainable energy production are robust enough to power 103 Danish homes per year while lightly touching the landscape. This interplay transforms the former industrial landscape into an interactive, lush public facility as well as an addition to the region’s network of avian habitat.

**Planning considerations**

The site’s proximity to the Lynetten Waste Water Facility imposes some restrictions on the site, informing our circulation and planting schemes. Responding to the area of high odor units (measured between 10-15 LE) crossing the site’s northeastern corner, the highest intensity of *Miscanthus* cultivation is sited in this undesirable zone.

***Miscanthus giganteus***

The increasing use of biomass plays a critical role in Denmark’s energy policy, or the Energy 21 action plan. Currently, efforts are concentrated on the exploitation of available biomass residues, mostly straw and wood. However, the contribution from energy crops is expected to increase steeply from 2012 to 2030. *Miscanthus giganteus* is a sterile hybrid that does not form fertile seeds. Propagation is by rhizome cutting. It has a high yield potential, particularly in coarse sandy soils, and has a low fertilizer demand, good for a site close to water. Not only can it withstand salinity, it is also effective in removing heavy metals from former industrial areas.

Because harvesting *Miscanthus* requires 3 meters, the ribbons’ spacing responds at 3m intervals. Ribbon spacing increases further from the terminal to not only allow the *Miscanthus* to be harvested more efficiently, but also to provide a recreational setting for Copenhagen’s densely populated city center. In order to create minimal impact on ground plane, new gravel paths reference existing foot traffic paths, for users to circulate under and through the arcs of ribbon canopy, walking amidst them as they touch the ground plane. The lowest part of the canopy is 2m and the highest is 8m. The site is seen from prominent Copenhagen destinations across the harbor. To create a focal point, the repetition of ribbons across the landscape culminates in the 70-meter monument.

*Miscanthus* belongs to the group of C4-photosynthesising plants, which are 30% more efficient at converting solar energy to production than agricultural crops with C3-photosynthesis. Ash and mineral contents are lowest when *Miscanthus* is grown in coarse, sandy soil. *Miscanthus* is harvested in December or April. Delaying the harvest until April or May decreases the moisture content in the plants from 60-70% in the fall to less than 20% in April. A delayed harvest is preferred because of the improved biomass quality, but it also results in yield losses of about 25%. The optimal planting rate is 16,000 rhizomes per hectare in order to get an establishment of 10,000 rhizomes per hectare. *Miscanthus* *giganteus* grows to a height of 250-300 cm and width of 90-120 cm.

**Ecological considerations**

Research suggests that an increase in the area of *Miscanthus* grown has temporary benefits for farmland bird populations during establishment. *Miscanthus* stands also contain higher quantities of large animals like mammals and birds than other herbaceous crops (i.e., corn or reeds. This is likely due to a greater diversity of canopy structure leading to a higher number and greater range of ecological niches.

Kalvebod Fælled is a nearby large bird area, located in southwest Amager. It is listed as an Important Bird Area (IBA), a designation given to globally important habitats. Additionally, it is a Conservation Area, an EU Bird Protection Area, and an EU Habitat. The Dansk Ornitologisk Forening (DOF) also considers Amager Fælled, located in the southwest corner of the island, an important bird habitat.

**Energy Calculations**

*Miscanthus giganteus*:

Yield: 15-20 tonne dry matter per hectare without irrigation; 30 tonne per hectare seen in ideal conditions

3.8 kWh/kg (20% moisture content) x 3 hectares x 20 tonnes

Total Annual KwH generated: 228,000

Powers 33 homes (Danish average home uses 7,000 kWh)

*Solar Ribbons:*

Copenhagen receives an average of 975kWhs of solar energy per square meter annually.

Nanosolar Thin Film CIGS: captures up to 20% of solar energy

3515 square meters of Ribbon top surface

Potential for 195 kWh with ideal solar orientation, actual yield expected 140 kWh

Total Annual KwH generated: 492,100 kWh

Powers 70 homes (Danish average home uses 7,000 kWh)

**TOTAL SKIBGRÆS ANNUAL KWH GENERATED: 720,100 (powers 103 homes)**

**Primary Materials**

Powder-coated 12.7mm marine-grade stainless steel (SAE 316 stainless steel or Alloy 20)

*Miscanthus giganteus*: Rhizomes.

Nanosolar Powersheets: This photovoltaic system is comprised of a composite of flexible solar panels, a geomembrane, and associated wiring to generate 140 kWh of electrical energy for distribution through the North Sea Offshore Grid.

**Maximum Environmental Impact Statement**

This project relies on low-impact energy efficient technologies in order to minimize impact on the existing site, while remediating and reclaiming the degraded land. *Skibgræs* takes into account the direct and indirect effects of the proposal on people, flora, and fauna; on soil, air, water, landscape, and climate; on material assets and the cultural heritage; and any secondary or tertiary factors.

*Miscanthus* production minimizes the metal contents in soils left over from industrial waste byproducts and takes up as much carbon as is released when it is burned, resulting in no net increase in CO2 into the atmosphere. One hectare produces the equivalent energy of 3,300 – 5,700 liters of light heating oil (an average medium-sized house will burn around 3,000 liters of oil per year, which releases 8.02 tons CO2). Additionally, *Miscanthus* *giganteus* sequesters significant amounts of carbon in its rhizome system, and organic matter in soil has been shown to increase under giant *Miscanthus* stands.

We anticipate potential negative effects on:

* **population**: none
* **fauna**: none
* **flora**: none
* **soil**: none, improved by the addition of *Miscanthus giganteus* cover; hardscaping around the perimeter will be minimal and made of pervious materials
* **water**: none
* **air**: none
* **climate**: none
* **noise/vibration**: small to moderate, mitigated by properly anchoring the monument
* **light/radiation**: small to moderate
* **architectural heritage**: none
* **archeological heritage**: none
* **landscape**: none
* **public access**: none
* **transportation**: none
* **use of raw materials**: small, monument construction phase
* **waste production**: none
* **indirect socioeconomic impacts**: none
* **cumulative impacts**: none